**NOAA's Integrated Ecosystem Assessment program:**
**Alaska Region 3-Year Work Plan (FY2016-FY2018)**

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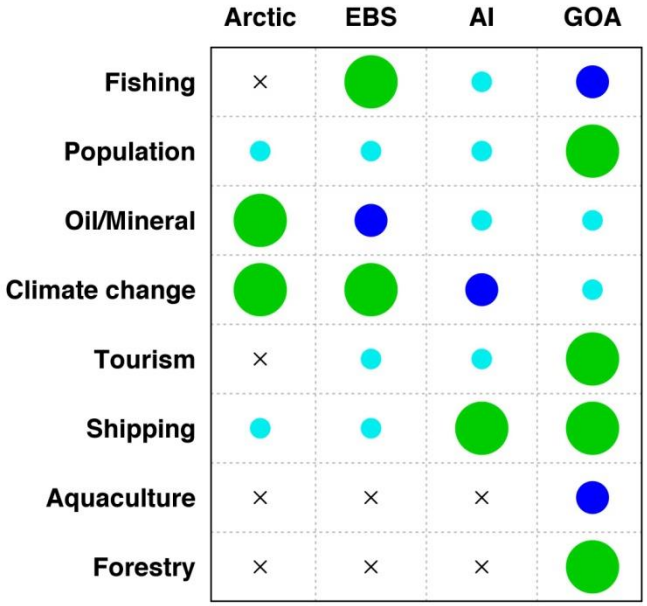
**Regional IEA Goal/Vision**:
The Alaska Complex of Large Marine Ecosystems includes the Gulf of Alaska (GOA), the eastern Bering Sea (EBS), the Aleutian Islands (AI), and Alaskan Arctic regions. Each of these regions is distinct and diverse in ecosystem structure and function, and shows a range of human drivers and pressures that differ significantly by region.




This 3-year plan for developing the Alaska IEA program sees the maturation of the Bering Sea IEA through the Bering Sea Fisheries Ecosystem Plan (FEP), and the initiation of an IEA program for the Gulf of Alaska region.

## Introduction:

Over the last 10-15 years, the North Pacific Fisheries Management Council (NPFMC) has actively engaged in bringing Ecosystem-Based Fisheries Management to the table through the development of annual Ecosystem Assessments, including ecosystem Report Cards, that are presented to the Council alongside quota decisions, the creation of an Aleutian Islands Fisheries Ecosystem Plan, the adoption of an Arctic Fisheries Management Plan with strong emphasis on ecosystem protections, the direct use of stock assessments that include climate drivers and other ecosystem effects, the inclusion of IEA team members on Plan Teams and other review boards, and through ongoing NEPA analyses.

Further, the North Pacific Research Board, in partnership with the National Science Foundation, recently competed a 5-year Bering Sea Ecosystem Program that included research from physics through plankton, fish, and with a strong emphasis on human dimensions and the use of broad research results for management – a Gulf of Alaska Integrated Research Program is currently in its final stages.

These programs have brought ecosystem-based science directly to the management table, including the development of Management Strategy Evaluations through stakeholder-driven workshops, working to integrate high-end climate and ecosystem modeling into management procedures, and by emphasizing outreach and direct stakeholder involvement on guiding research boards and priorities. This has resulted in the development of a specific range of modeling tools (FEAST and Multispecies Statistical Models) specifically adapted to implementing EBM under scenarios of climate change, with strong buy-in from the management and stakeholder community. These models have successfully completed the development stage, and a key aspect of immediate IEA work is to make these tools into an ongoing operational component of management without loss of current capacity built up through the previous research programs.

In February 2014, the Council adopted a vision statement for management to include "*environmental variability and uncertainty, changes and trends in climate and oceanographic conditions, fluctuations in productivity for managed species and associated ecosystem components, be based on best available science (including local and traditional knowledge), and engage scientists, managers, and the affected public*."

In December 2015, the Council initiated the development of a Bering Sea Fisheries Ecosystem Plan (Bering FEP). The guidance document specified that the Bering FEP should include modules consistent with a complete IEA loop; including stakeholder involvement, indicator development, scenario modeling, risk assessment, and management strategy evaluations. Two specified components of the Bering FEP requested by the Council were to:

- Evaluate the short- and long-term effects of climate change on fish and fisheries; and
- Create a series of conceptual models for the Bering Sea ecosystem.

The core activities of this 3-year plan focus on developing, maintaining, and updating the models required to evaluate climate change; these models have been developed and presented to the Council and are expected to play a major role in the Bering FEP. As a supplementary project, we propose the development of conceptual models for both the Bering Sea and Gulf of Alaska to support the Bering FEP and the initial stages of a Gulf of Alaska IEA program.

## REGIONAL GOALS, OBJECTIVES, ACTIVITIES, AND DELIVERABLES

***PRIORITY GOAL #1: Next generation ecosystem-based assessments and management strategy evaluations for the Bering Sea***

The Alaska Fisheries Science Center, in conjunction with the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program (BSIERP) and the OAR Pacific Marine Environmental Laboratory (PMEL), have developed a major set of collaborative links that integrate Bering Sea field research, in particular physical data from PMEL, lower trophic level and early life history monitoring of fish from AFSC surveys, and modeling capabilities from AFSC and PMEL into a set of data and modeling tools designed to substantially inform management decisions, especially with respect to future climate change.

This priority goal develops, supports and maintains Bering Sea models needed to inform Ecosystem-Based Fisheries Management (EBFM) at the AFSC and improve assessment methods and decision tools. Scientific information and tools developed and maintained as part of this goal include oceanographic models (ROMS), climate-enhanced food-web models such as Ecosim, bioenergetics-based multi-species catch-at-age models (CEATTLE), climate-enhanced ecosystem and single-species assessment models, bioenergetics models, climate-enhance recruitment models, and statistical analyses of ecological interactions to conduct Ecosystem Risk Assessments and Management Strategy Evaluations. Current IEA funding will be used to improve these approaches for Arctic and subarctic regions, and funding from FATE, SAAM, and S&T will be used to project models forward under future climate conditions as part of 3 year a climate change management strategy evaluation (ACLIM). This priority is a joint project of OAR/PMEL and NMFS/AFSC.

**Objective #1:** *The updating and running of an end-to-end climate-driven modelling suite for the Bering Sea ecosystem, to produce results requested by the North Pacific Fisheries Management Council as part of analyses for the Council's Fisheries Ecosystem Plan (core).*

**Deliverables:**

- Annual data preparation of atmospheric forcing and boundary conditions for nowcast and 9-month forecasts.
- Annual production of a nowcast and 9-month ahead forecast of oceanographic conditions relevant to key ecological processes in the Bering Sea, contributed as indicators to the Annual Bering Sea Ecosystem Assessment, using ROMS-BERING model.
- Annual estimates of gear-specific fisheries catch produced in formats suitable for driving ROMS-based fisheries models.
- Development of spatially-explicit fisher behavior prediction models for the ROMS modeling system.
- Annual production of model-based indicators (e.g. natural mortality from the CEATTLE multispecies model) for incorporation into stock assessments.
- Further runs of climate-based model outputs for management strategy evaluation under guidance of the NPFMC Bering Sea FEP team.
- Assessment of model skill for best available modeling system (every 3 years).

## Priority Goal #1 Workplan

| Deliverable (from above) | Key Tasks/Input/ Deliverable | Expected Completion Date | Responsible LO/ Partner (or Person) | Progress Reporting |
|---|---|---|---|---|
| End-to-end modeling | ▪ Atmospheric forcing data | Annually, October | OAR/Stabeno | |
| End-to-end modeling | ▪ Nowcast and 9-month forecast | Annually, November | OAR/Stabeno | |
| Fisheries inputs | ▪ Fisheries inputs | Annually, August | NMFS/Aydin | |
| Fisher prediction models | ▪ Fisher prediction models | 2018 | NMFS/Aydin | |
| Annual indices (multispecies models, food web models) | ▪ Annual indices (multispecies models, food web models) | Annually, October | NMFS/Aydin | |
| FEP-requested modeling results | ▪ FEP-requested modeling results | Sept 2017 | NMFS/Aydin | |
| Model skill testing for 9-month forecast | ▪ Model skill testing for 9-month forecast | 2018 | NMFS/Aydin | |

## *PRIORITY GOAL #2: The development of Ecopath and Ecosim R modeling tools*

Ecopath and Ecosim are food web modeling tools in use in all NOAA regions. However, the current most-used version of the software is "black-box" and does not allow code review or provide statistical tools suitable for "stock assessment" quality reviews. For the past several years, IEA researchers at both the Northeast and Alaska Centers have collaborated to develop an open R package (library) to implement and support Ecopath and Ecosim, and work in particular with the needs of NOAA users of the tools to develop the software. This priority goal is a continuation of Alaska's portion of this work.

**Objective #1:** *Complete and release a set of Monte-Carlo simulation and fitting tools designed to quantify uncertainty within Ecopath and Ecosim models (base).*

**Deliverables:**

- Workshop in Woods Hole between NE and Alaska programmers (funds for Alaska portion of travel), with anticipated invitations to other IEA Regions.
- Ecosystem sensitivity routines published as a supplement to the planned-release Rpath R library.
- Ecosystem fitting routines published as a supplement to the planned-release Rpath R library.

**Objective #2:** *Visualization and indicator production tools for Ecopath and Ecosim (supplemental).*

**Deliverables:**

- A set of network and visualization tools to be used for food web models and modeling.

### Priority Goal #2 Workplan

| Activity (from above) | Key Tasks/Input/ Deliverable | Expected Completion Date | Responsible LO/ Partner (or Person) | Progress Reporting |
|---|---|---|---|---|
| Rpath tools | ▪ *Sensitivity routines* | *June 2017* | *NMFS/Aydin* | |
| Rpath tools | ▪ *Fitting routines* | *June 2017* | *NMFS/Aydin* | |
| Rpath visualizations | ▪ *Visualizations* | *Sept 2017* | *NMFS/Aydin* | |

## *PRIORITY GOAL #3: Comparative conceptual modeling and scoping of the Bering Sea and Gulf of Alaska*

The Council's Bering FEP guidance included the recommendation for the creation of conceptual models of ecosystem structure and function. As per the document, the models will "help the Council in assessing tradeoffs of management actions on different components of the ecosystem, leading to more informed decision making."

However, given the diversity of Alaskan ecosystems, it is likely that different types and styles of conceptual model may be appropriate for the different ecosystems in Alaska. In particular, the recently-completed North Pacific Research Board's Gulf of Alaska Integrated Research Program (GOA-IERP) stressed the importance of global connectivity between local areas; for example spawning areas in the eastern GOA and settlement areas in the western GOA. In contrast, the focus on the eastern Bering Sea is on broad areas of ice-mediated productivity. Further, on the human dimensions scale, the GOA possesses a greater diversity of sub-ecosystems and communities (e.g. southeast Alaska, and Kodiak) that open the possibility for both local and global nested conceptual models. For this project, conceptual models for the Bering Sea and Gulf of Alaska will be developed in parallel.

For the Bering Sea, this will be performed in the context of the Bering FEP team, which is expected to include scientists, community members, and stakeholders that are part of a "mature" IEA program.

For the Gulf of Alaska, the conceptual models will be seen as the scoping step in developing an extended work plan for the GOA IEA in subsequent years (2017-2018). A special emphasis will be on the development of local community conceptual models versus "whole ecosystem" models, with potential foci around key communities such as Sitka or Kodiak. This work will

also be done in collaboration with the North Pacific Research Board's Gulf of Alaska synthesis project, taking place in 2016-2017.

**Objective #1:** *Conceptual model for the Bering Sea and Gulf of Alaska (supplementary)*

**Deliverables:**

- Publication of a conceptual model of the Bering Sea in collaboration with the Bering FEP team.
- Publication of a conceptual model of the Gulf of Alaska, with a focus on the interaction between local communities and ecosystem-wide processes.
- The production of a suite of key indicators for the Gulf of Alaska region in support of key conceptual model elements.

## Priority Goal #3 Workplan

| Activity (from above) | Key Tasks/Input/ Deliverable | Expected Completion Date | Responsible LO/ Partner (or Person) | Progress Reporting |
|---|---|---|---|---|
| Conceptual models | ▪ *Bering Sea* | *June 2017* | NMFS/Aydin | |
| Conceptual models | ▪ *Gulf of Alaska* | *Sept 2017* | NMFS/Aydin | |
| Conceptual models | ▪ *Gulf of Alaska indicators* | *December 2016* | NMFS/Aydin | |

## Additional Methodological Information:

- *How will these outcomes result in a complete iteration of the IEA loop and/or advance IEA activities?*

The end-to-end modeling component for the Bering Sea (Priority 1) functions under the guidance of a stakeholder team assembled under the guidance of the Council's ecosystem committee, develops climate-based indicators, and models results for management strategy evaluation, including estimation of uncertainty for risk analysis. Therefore, in the context of the FEP, it provides the completion of a full IEA loop over the three years of the project. Priority 2 (food web software development) primarily addresses modeling and associated management strategy evaluations, while Priority 3 (conceptual modeling) is seen as a tool for structuring the IEA loop as a whole.

- *What scientific advancements are anticipated from this work plan that are likely transferrable to other regions?*

In particular, the food web software development (Priority 2) is directed at the development of a decision-support tool that is in demand throughout NOAA; completion of this R package will enhance the NOAA-wide use of these tools.

- *How will human dimensions and climate change be incorporated into the work?*

The Bering FEP guidance document includes specific modules on human dimensions and climate change; the human dimensions work will be performed in collaboration with the Alaska Regional office, while climate change work is detailed in Priority 1, here.

- *Will this research transition into or inform actionable management decisions?*

The Bering FEP guidance document outlines specific steps for the ecosystem-based management results provided by the IEA program to be incorporated into the fisheries stock assessment cycle in Alaska, primarily through ecosystem information to be provided in stock assessments or as part of the annual ecosystem assessment.

- *What management entities are engaged or will be engaged by this effort? How do you envision the work informing management decisions in your region? Are there specific pending management decisions that you aim to inform with this work?*

The primary audience for this work is the North Pacific Fisheries Management Council. This work is currently presented annually, as part of AFSC's Ecosystem Assessment, in the context of setting crab and groundfish quotas for Alaska. This information has been used in the past by the SSC to adjust quotas downward due to ecosystem (climate-based) concerns. The Bering FEP will formalize this process.

- *What steps will be taken to increase the probability that relevant management agencies make decisions informed by IEA products?*

The current major step is working closely with the NPFMC during the Bering FEP process, such that IEA products remain consistently in line with management expectations.

## End-Users (e.g. recipients/ beneficiaries of regional IEA work and impact):

The primary end-user is the North Pacific Fisheries Management Council and stakeholders associated with the Council; the requested work is primarily detailed in the included Bering FEP guidance document, approved by the council in December 2015.

In December 2014, the NPFMC Scientific and Statistical Committee (SSC) reiterated requests for continued presentation of ecosystem modeling and indicators in the annual Ecosystem Considerations, integration with single species stock assessment, and increased emphasis within the annual management process: "The SSC offers the following comments: "The SSC realizes that one of the most widely respected aspects of our Council process is our effort to assess the individual species in the context of the marine ecosystems in which they exist. The SSC wishes to emphasize the continued importance of the Ecosystem Chapter to the plan teams on an annual basis. In particular, it is important for annual updates to be brought to the attention of plan team members, so that relevant ecosystem considerations can be included in the annual SAFE chapters for each fish stock."

### Long-term Outcome(s):

The largest IEA challenge facing the Alaska Region is the diversity of large marine ecosystems (the Bering Sea, the Gulf of Alaska, the Aleutian Islands, and the High Arctic) with differing species, structures, climate responses, and human uses. Since IEAs are inherently place-based, the long-term vision for the Alaska program is individual (though coordinated) IEAs for each LME. On the research end, the North Pacific Research Board has met this challenge by rotating focus areas for Integrated Ecosystem Research Programs. The Bering Sea IERP completed in 2014 and key research results have been brought into IEA operations; the Gulf of Alaska IERP is scheduled for completion in 2017 and a similar process is anticipated. The High Arctic IERP is currently in the planning stages. The Alaska IEA program aims to develop IEAs for each LME in a similar fashion.

### Success:

The primary success metric is adopting IEA products in a management context; in the near-term, this means the successful provision and inclusion of IEA science in the Bering Sea FEP. The resulting FEP should formalize annually-provided IEA information within the Council process so that the Council can take informed ecosystem-based decisions; the completion of such an IEA for each LME (and the setup of supporting systems for monitoring and reporting indicators and models on an ongoing basis) would be considered success.

### Leveraging:

The AFSC currently provides $100K annually in in-kind salary support for IEA activities. Further, funding for indicators and modeling is leveraged from FATE project funding and FTE time ($200K/year, primarily through the ongoing ACLIM project). To implement EBFM, the IEA group has worked closely with the North Pacific Research Board's Integrated Research Programs for the Bering Sea and Gulf of Alaska. In particular, the IEA team will work closely with the ongoing GOA-IERP project, a $17.6 million project over 7 years (currently in its final 2 years) to ensure that research results from the project are incorporated into conceptual models, indicators, and future modeling efforts.

## COMMUNICATION AND OUTREACH

The primary communication of IEA results is through the Council process. In particular, ecosystem results (indicators and modeling) are presented annually to the NPFMC's SSC, Advisory Panel, and Council in the context of quota-setting. The second vehicle for communication is the Ecosystem Assessment website (http://access.afsc.noaa.gov/reem/ecoweb) which is updated annually with ecosystem report cards, summaries, full assessment, and indicators.

IEA participants have given multiple presentations (3-5 per year) focusing on Alaskan communities such as Sitka, Kodiak, St. Paul, and Anchorage. This has included engagement with local schools as well as stakeholder and community groups.

## PAST ACCOMPLISHMENTS/ PROGRESS

Since 2012, the Alaskan IEA Program itself, despite modest funding, has seen multiple successes by leveraging limited funds with partnerships from other funding sources. In particular, IEA funding has been used to forge an ongoing partnership between the Alaska Fisheries Science Center (NMFS) and the Pacific Marine Environmental Laboratory (OAR) to develop and publish a set of multispecies models, coupled to long-term climate change projections for the Bering Sea, to establish a set of management scenarios that include spatial changes in fish population and human activities resulting from the projected loss of sea ice in the Bering Sea region. These models will continue to play a key role in Alaska's IEA toolbox. Specific products produced with partial or full IEA funding include:

1. The extension of high-resolution atmosphere-ocean models (ROMS-NPZ) with coupled plankton populations to provide and evaluate short-term (9-month) and long-term (40-year) forecasts of the Bering Sea under a range of climate scenarios;
2. The use and extension of the Multispecies Statistical Model (MSM, CEATTLE) a multispecies stock assessment model linked by species interactions, to evaluate multispecies control rules in a management strategy evaluation framework;
3. The development of the Spatial Economics Toolbox for Fisheries (FishSET) to improve predictions about fleet behavior under climate change.
4. The continued improvements of Alaska Ecosystem Assessments to improve indicator-based Report Cards (annual publications) and the extended development of management scenarios for testing reference points (multiple publications).